Registration of 'Juniper' Wheat

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ABSTRACT

'Juniper' (Reg. No. CV-1021, PI 639951) is a hard red winter wheat (*Triticum aestivum* L.) developed by the Idaho Agricultural Experiment Station and released in February 2006. Juniper was tested under the experimental numbers A91013W-1 and IDO575. It is a full-stature wheat released for very low rainfall, crop-fallow rotations of the Intermountain West and was released for its improved resistance to stripe rust (*Puccinia striiformis* Westend) and dwarf bunt (*Tilletia controversa* Kühn in Rabenh) and bread-baking quality compared with current full-stature cultivars. Juniper had an average yield in rainfed trials of 3290 kg ha^{-1}, compared with the other tall cultivars for this region, 'Weston' and 'Bonneville', which had grain yields of 3050 and 3180 kg ha^{-1}, respectively. Weston has undesirable baking quality due to short dough mixing time. Juniper has nearly a full minute longer mixograph mixing time compared with Weston ($p < 0.01$). Juniper also has similar snow mold tolerance (causal organism *Typhula* spp.) to Bonneville without the undesirable characteristic of late heading date and maturity. Juniper heads 3 d earlier than Bonneville.

'Juniper' (Reg. No. CV-1021, PI 639951) is a hard red winter wheat (*Triticum aestivum* L.) developed by the Idaho Agriculture Experiment Station and released in February 2006. Juniper was named for the town of Juniper, ID. Juniper was tested under the experimental numbers A91013W-1 and IDO575. It was released for its superior yield and quality compared with previous full-stature hard red winter wheat cultivars in the Intermountain zone of the western United States. Juniper is best adapted to low-rainfall, crop-fallow production systems.

Methods

Juniper derives from a cross, designated A91013W, with the pedigree IDO352/UT165093. IDO352 is a tall hard red winter wheat breeding line with a complex pedigree and breeding history, which is described in Windes et al. (1995). IDO352 was developed at the University of Idaho and carries novel resistance to dwarf bunt, which is caused by *Tilletia controversa* Kühn in Rabenh. UT165093 is a hard red winter wheat breeding line from Utah State University with the pedigree ID51022/'Manning'. ID51022 is a hard red winter wheat of uncertain parentage from the University of Idaho Moscow wheat breeding program, and Manning is a hard red winter wheat released from the Utah State University Experiment Station (Dewey, 1981). The A91013W cross was completed at Aberdeen, ID, in 1991, and nine F_1 seeds were planted in the field at Aberdeen during the winter of 1991–1992. Aberdeen has insufficient rainfall for normal winter wheat production and requires some supplemental irrigation to recover seed in most years. Therefore, all Aberdeen trials described hereafter were irrigated weekly from April to July to replace approximately 75% of evaporative loss. This approximated moisture stress of the rainfed winter wheat production zones of southern Idaho. Irrigation methods and procedures for estimating reduction of irrigation are described in Guttieri et al. (2005). The progeny of the cross was advanced each year at Aberdeen by the bulk method for the F_2 and F_3 generations. In 1994–1995, the seed of the F_4 family was planted at Aberdeen, and 200 heads were selected from a population of approximately 1000 plants. Seed of the selected heads were visually inspected, and head selections with small, shriveled, or diseased grain (primarily *Alternaria* spp.) were discarded. Approximately 86 head rows were seeded in the field at Aberdeen in 1995–1996, one head selection to one 1-m-long row. Head rows were selected and harvested based on uniformity and resistance to field infection from stripe rust (*Puccinia striiformis* Westend.) and common bunt (*T. caries*). Inoculation, races, and evaluation of common bunt resistance were as described in Windes et al. (1995). Headrow grain was selected for strong gluten using a modification of the sodium duodecyl-sulfate–sedimentation method (Guttieri et al., 2004). Six headrow selections were advanced to unreplicated testing at Aberdeen and grown in 2-m^2 plots in 1996–1997. Three of those selections

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Table 1. Performance of hard winter wheat cultivars in southern Idaho, four-year average.†

Cultivar	Class‡	Spring stand	Heading date	Plant height	Grain yield	Test wt.	Grain protein	Grain yield	
								Rockland	Preston
		%	d from Jan 1	cm	kg ha^{-1}	kg m^{-1}	g kg^{-1}	kg ha^{-1}	kg ha^{-1}
Juniper	HRW	89	156	102	3290	802	134	2340	4210
Bonneville	HRW	90	159	89	3050	803	141	2120	3930
Boundary	HRW	88	157	74	3470	782	127	2530	4350
Deloris	HRW	87	156	74	3240	799	124	2650	4610
DW	HRW	87	156	87	3630	799	132	2280	4200
Eltan	SWW	89	160	79	3630	775	123	2710	4770
Gary	HWW	90	157	84	3560	790	123	2410	4500
Utah 100	HRW	87	156	87	3470	784	131	2340	4620
Weston	HRW	85	154	94	3180	810	137	2060	4140
Standard error		1.3	0.4	1	9	3	0.3	15	21
No. of environments		16	12	20	16	12	9	4	4

†Rainfed trials at Rockland, ID, 2002 to 2005; Preston, ID, 2001, 2003 to 2005; Roy, ID, 2002 to 2005; Tetonia, ID, 2001 to 2004; Arbon, ID, 2004 to 2005. Heading date and plant height data includes irrigated trials at Aberdeen, ID, 2001 to 2005. When data was collected at an environment, information was recorded for all cultivars at that environment. Not all traits were recorded in all environments.

‡HRW, hard red winter; SWW, soft white winter.

were advanced to preliminary replicated testing in rainfed trials at Preston and Rockland, ID. Rainfed trials for 1997–1998 and in all subsequent years were managed as described in Souza and Sunderman (1992). The experimental design of trials in 1997–1998 and all subsequent years used 10 × 10 partial lattice designs (three replications). One line, designated A91013W-1, was tested in advanced replicated testing in 1998 to 2005 at Preston, Rockland, Roy, and Tetonia, ID. The Arbon, ID, location was included in the last two years of testing. In 2000 A91013W-1 was designated IDO575 and placed in the Western Regional Winter Wheat Nursery in 2001, 2002, and 2003 (Garland-Campbell and Little, 2001, 2002, and 2003). In 2003 approximately 200 heads of IDO575 were selected at Aberdeen and planted as headrows at Aberdeen in 2003–2004. Rows of IDO575 that were uniform for height, heading date, and head type (approximately 150) were harvested and planted as plots to form the breeder seed for the cultivar Juniper. Juniper was evaluated in on-farm testing by the University of Idaho Cooperative Extension Service in 2005 and by the Pacific Northwest Wheat Quality Council in 2005. Juniper is uniform for plant type without obvious phenotypic variants and has remained stable during six generations of evaluation, 1999 to 2004.

Characteristics

Juniper is most similar in appearance to the cultivar Weston (PI 603040). Juniper has an unpigmented coleoptile and a prostrate seedling growth habit. At an average height of 102 cm in 20 trials (Table 1), Juniper does not appear to have genes for semidwarf plant type as it is taller than the full-stature cultivars Weston (93 cm, $p < 0.05$) and Bonneville (89 cm, $p < 0.01$, Souza et al., 1995). Juniper has dark green foliage with slender, recurved, and nontwisted flag leaves. The inflorescence of Juniper is awned, mid-dense, and tapered, with glumes that are wide, midlong, with oblique shoulders and acuminate beaks. The last internode of the rachis is pubescent. The auricles and anthers of Juniper are unpigmented. Juniper has bronze chaff color at maturity. Seed of Juniper is ovate, with a shallow, wide crease and angular cheeks, similar to Bonneville. The brush on Juniper's seed is short in length and not collared. Juniper has large seed, averaging 39 mg per kernel in five years of Aberdeen trials, similar to Bonneville (39 mg per kernel), but smaller than Weston (42 mg per kernel, $p < 0.01$).

Juniper is a mid-maturity winter wheat, with an average heading date in Idaho of 156 d after January 1, (12 field trials, 2001 to 2005), 3 d earlier than Bonneville and 2 d later than Weston ($p < 0.05$, Table 1). In most trials from 1999 to 2005, no lodging occurred; however, in six trials where lodging occurred, Juniper had an average score of 12% lodged plants, similar to Bonneville (19% lodged), but with less lodging than Weston (28% lodged, $p < 0.05$). In 16 rainfed yield trials grown in Idaho from 2001 to 2005, Juniper had an average grain yield of 3290 kg ha^{-1}, similar to Bonneville (3050 kg ha^{-1}) and Weston (3190 kg ha^{-1}, Table 1). Juniper was released to replace Weston in the crop-fallow rotations where only one grain crop per two years is produced. Growers prefer very tall cultivars in these low rainfall zones because seeding often must place grain in moisture accumulated during the fallow period, which is below the cultivation zone (10–15 cm deep) for weed control during the fallow year. Yield trials at Preston and Rockland were produced on two-year, crop-fallow rotations due to limited rainfall at these locations. In these trials, Juniper is equal in grain yield to Weston and Bonneville, the other tall cultivars grown on crop-fallow rotations (Table 1). In Western Regional Nursery trials (Garland-Campbell and Little, 2001, 2002, and 2003), across the U.S. Pacific Northwest, 2001 to 2003 (Table 2), Juniper had an average grain yield of 4030 kg ha^{-1}, compared with 3940 kg ha^{-1} for the tall-stature winter wheat 'Finley' (Donaldson et al., 2000) and 4621 kg ha^{-1} the semidwarf 'Boundary' (Souza et al., 1999). Juniper had an average grain volume-weight in southern Idaho rainfed trials (12 trials, 2001–2005) of 801 kg m^{-3}, similar to Bonneville (803 kg m^{-3}), and less than Weston (809 kg m^{-3}, $p < 0.05$). In nine rainfed yield trials grown in Idaho from 2001 to 2005, Juniper had an average grain protein concentration of 134 g kg^{-1}, compared with 141 g kg^{-1} for Bonneville, and 137 g kg^{-1} for Weston (Table 1).

Table 2. Performance of Juniper wheat in Western Regional Nursery from 2001 to 2003.

Cultivar	Grain yield				Summary of all locations reporting data for 2003					
	3-yr avg.	2003	2003	2003	Test wt.	Heading date	Plant height	Lodging†	Spring stand	Grain protein
	———— kg ha^{-1} ————				kg hL^{-1}	d from 1 Jan.	cm	0–9	%	g kg^{-1}
Juniper	4030	4030	3940	4100	785	156	116	0.7	75.5	146
Boundary	4630	5240	4350	4290	768	156	88	0	85.9	143
Finley	3940	3760	3990	4060	789	156	108	1.7	68.7	142
Kharkov	3320	3290	3330	3340	777	155	111	5.7	76.1	154
No. of locations	29	7	11	11	5	4	7	1	3	3

†Lodging score, 0 = no lodging, 9 = no plants standing.

Based on greenhouse evaluations by X. Chen, USDA-ARS, Pullman WA, Juniper has adult plant resistance to stripe rust races PST-78, PST-17, PST-37, PST-45, and PST-43, with seedling resistance to stripe rust races PST-78, PST-17, PST-37, and PST-45, but seedling susceptibility to PST-43 (Garland-Campbell and Little, 2001). In four years of field trials (2001–2005) at Pullman and Mount Vernon, WA, Juniper had moderate high temperature, adult plant resistance to stripe rust with reaction types varying between Type 0 (asymptomatic) and Type 8 (active sporulation) with no more than 10% of the leaf area covered in lesions. In the same trials, susceptible spreader rows had 90% or greater of their leaf area covered with stripe rust pustules. Bonneville and Weston both had similar reaction types to Juniper, with Bonneville having up to 40% of leaf area covered in lesions, while Weston had up to 10% leaf area covered with lesions. The race spectrum of the stripe rust pathogen during this time period was complex (dominant races: Pst 98 and Pst 100; X. Chen, personal communication, 2005). In 2005 replicated field trials at Aberdeen, Rockland and Preston, ID, Juniper had a resistant type 0 reaction to stripe rust infection, compared with moderately susceptible type 4 reactions for Bonneville and type 5 to 6 reactions for Weston (dominant races: Pst 98 and Pst 100; X. Chen, personal communication, 2005). In the same trials, the susceptible hard red winter wheat 'Deloris' (Hole et al., 2004) had susceptible type 8 reactions at all locations.

On the basis of 2001 seedling resistance evaluations by the USDA-ARS Cereal Disease Laboratory, Juniper is postulated to carry *Sr36* and additional unknown genes for stem rust (*Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn.) resistance. Juniper's reaction to leaf rust *(Puccinia recondita* Roberge ex Desmaz. f. sp. *tritici*) is unknown. In three years of Western Regional Nursery evaluations at the Green Canyon site (near Logan, UT), Juniper had excellent resistance to dwarf bunt, with an average rating of 0% infected tillers compared with the susceptible check cultivar Cheyenne (PI 192268), which had an average of 90% of tillers bunted. At the same location in University of Idaho evaluations from 2001 to 2005, the highest level of dwarf bunt infection observed in Juniper was 2% of tillers bunted, similar to Bonneville (maximum of 2% bunted tillers) yet better than Weston (maximum 15% bunted tillers). Juniper has moderate resistance to snow mold based on evaluations in 15 southern Idaho trials from 1999 to 2005 where snow mold significantly reduced spring stands; Juniper had a spring survival of 86%, similar to the resistant cultivar Bonneville (86%), and greater than the susceptible cultivar Weston (77%, $p < 0.01$).

The University of Idaho Wheat Quality Laboratory evaluated the end-use quality of Juniper by milling and baking samples of each entry from 19 yield trials grown in southern Idaho from 2001 to 2004. Wheat was milled using a Quadrumat Senior experimental flour mill (AACC 26-21A), a Mixograph was used to measure dough strength (AACC 54-21), and a pup-loaf bread bake (AACC 10-10B) was used to assess loaf volume (American Association of Cereal Chemists, 2000). Juniper had a milling yield of 666 g kg^{-1}, similar to Weston (670 g kg^{-1}) yet less than Bonneville (687 g kg^{-1}, $p < 0.05$). Juniper, Bonneville, and Weston each had an average flour protein of 121 g kg^{-1}. Mixograph dough mixing time for Juniper was 2.6 min, longer than Weston (1.7 min, $p < 0.01$, Table 3) but less than Bonneville (3.1 min, $p < 0.01$). The mixing tolerance of Juniper, as measured by the angle of the Mixograph curve arriving and departing from peak, is similar to Bonneville, with angles of 75.5° and 74.3°, respectively. Both Juniper and Bonneville had greater mixing tolerance than Weston, which had an angle of 65.2° ($p < 0.01$). Juniper had an average pup-loaf volume of 1059 mL, similar to Bonneville

Table 3. Summary of four years of milling and baking evaluations of hard red winter wheat grown in Idaho, 2001 to 2004, 14 environments and 19 independent baking evaluations.

Cultivar	Flour protein	Flour yield	Mixograph			Bake time	Bake absorption	Loaf vol.	Texture	
			Peak	Height	Tolerance				Exterior score	Interior score
	g kg^{-1}	g kg^{-1}	min	cm	degrees	min	g kg^{-1}	mL	0–5	0–5
Juniper	121	666	2.6	6.3	75.5	2.2	59.9	1059	1.3	1.5
Bonneville	121	687	3.1	6.0	74.3	2.6	60.2	1024	1.4	1.6
Boundary	109	672	3.1	5.9	78.8	2.9	57.4	921	1.3	1.5
DW	112	663	3.8	6.2	75.7	3.3	58.8	1058	1.4	1.6
Gary	107	656	3.7	5.8	78.0	3.5	57.4	954	1.2	1.5
Utah 100	110	659	2.9	6.2	74.5	2.6	58.4	1009	1.4	1.4
Weston	121	670	1.7	6.9	65.2	1.6	60.3	1064	1.5	1.5
Standard error	4	6	0.2	0.2	2.1	0.2	0.7	36	0.1	0.1

(1024 mL) and Weston (1064 mL, Table 3). Alkaline noodles of Juniper were sheeted from composite samples of the Western Regional Nursery in 2001, 2002, and 2003. Noodle sheet color was measured in Commission Internationale de l'Eclairage (CIE) tristimulus color space (L^*, a^*, b^*) using a Minolta CM-2002 spectrophotometer (Minolta Camera, Chuo-Ku, Osaka, Japan) with a 50-mm measurement aperture. Juniper's alkaline noodles were bright 24 h after sheeting (CIE-L^* 78.3), compared with Finley (CIE-L^* 77.8) and Boundary (CIE-L^* 77.7; Garland-Campbell and Little, 2001, 2002, and 2003).

Availability

Seed of Juniper will be maintained by the University of Idaho, Foundation Seed Program, 3793 North 3600 East, Kimberly ID 83341. Plant Variety Protection will not be sought for Juniper, and seed will be freely distributed to all interested parties. All generations of pedigree seed (Foundation, Registered, and Certified) are approved for production by the University of Idaho Foundation Seed Program.

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